M.Breidenbach, J.Brau, J.Jaros H.Weerts
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Critical Questions for SiD

Draft 4

SiD has the major assumption that energy flow calorimetry is essential for good jet resolution. It is time to demonstrate that the assumption is true, and to determine rational major detector parameters. The other major assumption is that the detector cost is constrained. This assumption will not be buttressed by simulation, but is considered reasonable by most. The energy flow demonstration is a simulation and reconstruction strategy issue, as are most of these questions. However, there are a few specific hardware developments that are crucial to determining "rational major detector parameters".

For a fixed detector technology, bigger appears to be better. There is general agreement that the numerator of an energy flow figure of merit is BR^2. (R is the outer radius of the tracker or the inner radius of the EMCal, probably different by about a cm.) If the cost of the calorimeter can be reduced without affecting performance, then BR^2 can be increased. Therefore a primary question is:

1. Can the number of layers of Si in the EMCal (currently 30) be reduced?
2. Do we need 30 radiation lengths? Is 25 or 20 enough?
3. Would a tungsten based Hcal with 2X0 thick W ease the EMCal requirements?

Using the latest version of the parametric detector calculator, increasing the tracker radius (from 1.25 m) at fixed B=5T cost about \$2.1M/cm. If BR^2 is held fixed at 7.8 Tm^2 , then increasing the tracker radius (from 1.25 m) costs about \$0.6M/cm. Note that the baseline design of R =1.25 m and B=5T is a cost minimum if B=5T is considered a maximal field. So assuming an EMCal with gaps of 1 mm and pixels small compared to the Moliere radius, and sampling in depth often compared to the Moliere radius, then:

4. Are the EMCal assumptions above realizable (Physical prototype required)?
5. Is BR^2 =7.8 sufficient for the physics benchmark processes?
6. Is the improvement expected from increasing R at fixed BR^2 justified by the improvement in physics benchmark performance? Why would this improve things ?
7. Can a reasonable energy flow figure of merit beyond BR^2 be demonstrated by simulation and reconstruction by January of 2005? This should be analogous to understanding the performance variation with B, R, and the calorimeter properties. It is likely that calorimeter means both EMCal and HCal. Are there issues for the z position of the forward calorimeters.

The baseline assumption is that the HCal is inside the coil, and that it is 4 Λ thick (nominally 34 layers of stainless 20 mm thick with 10 mm gaps).

8. Is this HCal configuration sufficient for the benchmark physics processes?
    a. Is this the "right" radiator? How about tungsten?
    b. How about more sampling, and is 4 Λ sufficient?
    c. The gaps are expensive because they drive out the coil radius. Could they be reduced?
    d. 1 to 2 cm square pixels have been assumed. Is this right, particularly if the HCal density is increased?
    e. Can thin, cheap, reliable, good resolution detectors be made? (Physical Prototype required) (Note that Si is out of the question!!)

The superconducting solenoid is large, with more than a GJ of stored energy. There are concerns that the hoop stress in a 5T, R_{coil}=2.6 m might be excessive. In addition, the coil is a major cost driver, and it thus affects directly what BR^2 might be within the cost constraints.

9. Are there serious technical problems with a (thick) solenoid of these nominal parameters? Does the addition of serpentine correction coils for a crossing angle introduce horrible problems?
10. What is a rational cost parameterization for coils of this scale?

The barrel tracking and momentum measurement are baselined as 5 layers of pixellated vertex detector followed by 5 layers of Si strip detectors (in ~10 cm segments) going to 1.25 m. The momentum resolution for found tracks seems excellent.

11. Does it need to become more complicated?
12. Develop a baseline for the Forward direction.
13. Does this system find tracks well? What about machine and physics backgrounds?
14. Are there issues regarding K0's and Λ's i.e. can they be detected efficiently ?
15. Demonstrate (if true) the need to minimize tracker material to minimize multiple scattering.

There are many other important questions that must be studied, but still do not seem to drive the basic design or challenge the fundamental strategy of SiD. For illustration, some of these questions are:

1. What is a rational technology and a more detailed design for the VXD?
2. What is the technology for the muon trackings? Should it be the same as the HCal?
3. What is a design for the very forward calorimetry?